

Heterostyly and breeding mechanism of *Nymphoides cristatum* (Roxb.) O. Kuntze¹

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(With two text-figures)

Nymphoides Hill. (*Limnanthemum* Gmel.) of Menyanthaceae is a cosmopolitan hydrophyte, species of which show variation in floral morphology and mechanism of reproduction. Ornduff (1966) noted dimorphic heterostyly in many species, along with an incompatibility system. According to him, heterostyly has evolved into dioecism in this genus. I studied the South Indian species with regard to this aspect. The project was financed by the University Grants Commission.

METHOD AND MATERIAL

The study was conducted in two steps, concentrating on *Nymphoides cristatum* (Roxb.) O. Kuntze. Extensive field survey was carried out to note range of distribution and composition of natural populations. Experimental investigation was the second step.

Morphology was studied on fresh material collected from different localities. For breeding experiments plants were grown in special tanks made insect-proof with thin wire net and glass. Steel needles sterilized with rectified spirit were used to transfer pollen in artificial pollination. Plants were kept in insect-proof tanks before and after pollination.

DESCRIPTION

Nymphoides cristatum (Roxb.) O. Kuntze. is a rhizomatous herb with floating petiole-like branches and alternate leaves. Lamina is deeply cordate, up to 10 cm in diameter. Flowers arise in cluster from a vagina at the junction of branch and petiole. Flowers are long-pedicellate, white with yellow centre, 1-1.5 cm in dia., characterised by a me-

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dian vertical flap of petal lobes. Stamens 5, free, epipetalous; anthers yellow, introrse. Androeceum sterile in some. Gynoeceum superior with unilocular ovary, conical style, bilobed stigma and 3-5 ovules on 2 parietal placentas. Seeds lenticular, finely echinulate.

OBSERVATIONS

N. cristatum is widely distributed in Kerala, thriving best in shallow open fresh-water, forming consociations or associations with other aquatics. In permanent waters, it is perennial. Flowering is seasonal in the field but plants in cultivation flower throughout the year. There is normal vegetative propagation through fragmentation.

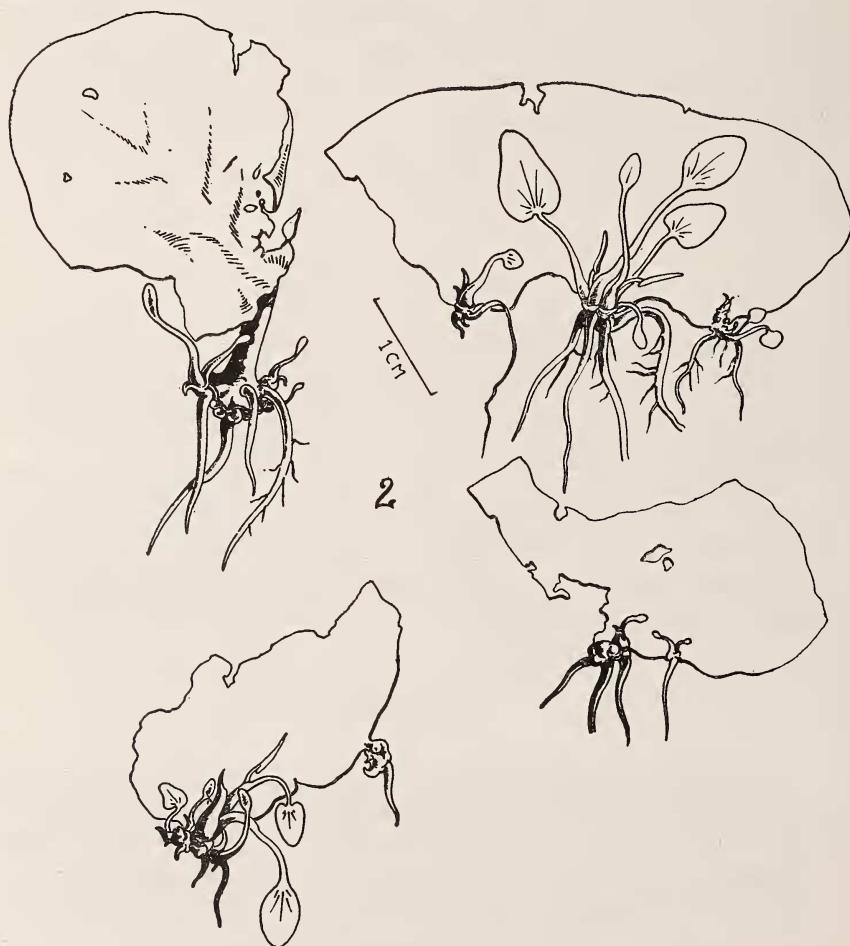


FIG. 2. Leaves with 'bulbils'.

Vegetative propagation through leaves, is common. As some tanks began to dry up in hot season, branches and leaves became progressively smaller. Some of the leaves were injured or broken. From the edges of the wounds, leafy buds with their own adventitious roots sprouted (Fig. 2). When transplanted, they grew up into normal plants.

There are no dormant buds concerned with the formation of these bulbils and they appear anywhere on the lamina and even on broken end of petiole. First step was formation of callus-like growth at the broken edge. Primordia of roots and then leaves appear soon. With the decay of lamina, the bulbils became free. This phenomenon is not found in healthy plants under favourable conditions. Apparently, increase in temperature and drought induce it. Plants facing destruction are trying to produce as many progeny as possible. If drought is not prolonged, the bulbils have a chance of survival.

Sexual reproduction:

N. cristatum is gyno-dioecious, having hermaphrodite and female plants. Flowers of these two forms (Fig. 1) are alike externally, but female has reduced, sterile stamens. Proportion of these two forms in natural populations is variable. Due to vegetative propagation, any one form may outnumber the other, but large well established populations always have both. Results of population counts made in different localities are given in Table 1.

TABLE 1
SEX RATIO IN POPULATIONS OF *N. cristatum*

Locality	Total No. of plants	Bisexual	Female
Tellicherry	48	30	18
Calicut	17	12	5
Badagara	31	18	13
Alwaye	43	21	22
Palghat	11	8	3
Chittur	13	5	8
Total	163	94	69

Monomorphic populations are rarely found in restricted spots like a small ditch. Growth of population being largely through vegetative means, they may be monomorphic during early stage, especially female ones.

Bisexual plants were grown in insect-proof tanks. They produced 512 flowers during the period of observation but only seven fruits were formed. The same tanks were kept open, allowing insect visit. Out of 200 flowers formed, 192 produced seed-bearing fruits. It is clear that

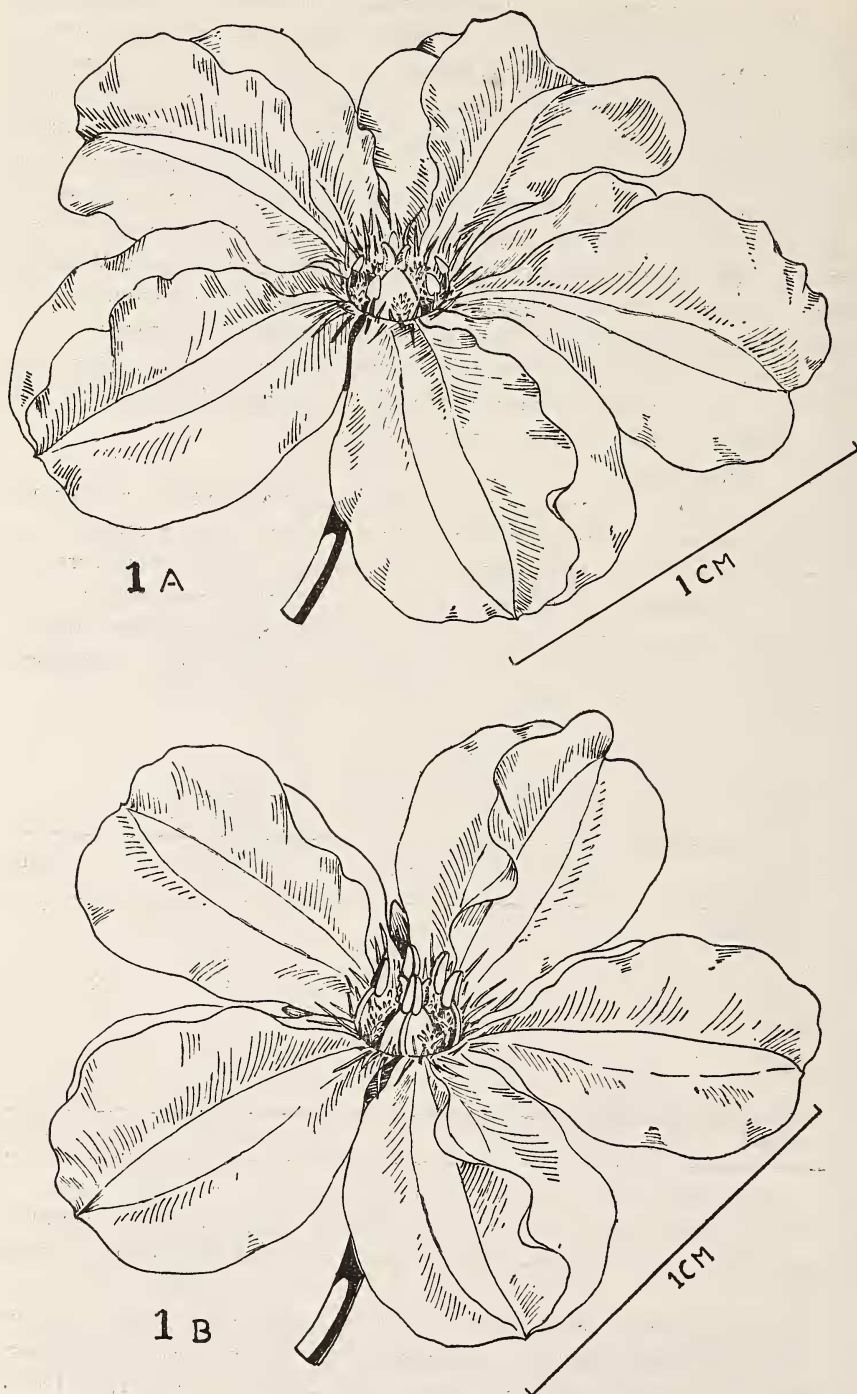


FIG. 1. Flowers: 1 A. Female; 1 B. Bisexual.

insects are necessary for pollination. Artificial pollination of bisexual flowers proved their self-compatibility. Female plants were grown first in insect-proof tanks and then in open tanks in isolation, with no bisexual plant in vicinity. In both cases hundreds of flowers were formed but not a single fruit. Then female flowers were pollinated with pollen from bisexual flowers. Out of 100 flowers, 91 produced fruits with 3-4 seeds, 4 produced 1-2 seeded fruits and 5 flowers withered. Evidently, female plants depend upon bisexual plants for pollen, got through insects.

DISCUSSION

Floral structure shows that gyno-dioecism of *N. cristatum* is derived from heterostyly which is common in the genus. According to Hildebrand (1867) and Darwin (1877) dimorphic heterostyly is an adaptation to promote outbreeding and a step towards dioecism. It has since been found to be associated with an incompatibility system also. In some taxa, heterostyly has given way to inbreeding but a breakdown to increased outbreeding is found in Rubiaceae and Menyanthaceae (Ornduff 1966). This raises doubts about heterostyly being an adaptation for outbreeding. Where there is self incompatibility, heterostyly is unnecessary for outbreeding. Examining the pollen load on stigma of several heterostylous taxa, Ornduff (1966) found that heteromorphism does not promote 'legitimate' pollination. The conventional explanation of the mechanism of heterostyly is more a theoretical probability than a practical reality.

Heterostyly is a stage in the morphological modification leading to dioecism which ensures outbreeding. Self incompatibility can serve the same purpose but there is possibility of its breaking up and reversion to self fertility. So in many taxa like *Nymphoides*, incompatibility system is progressing into dioecism. Heterostyly, according to Crowe (1964) is only "degenerate form of homomorphic incompatibility from which it arises by loss of alleles". Similar view is held by Vuilleumier (1965). The two characters are governed by separate genes (Ernst 1936; Lewis 1954) and so there is possibility of any one being strengthened or weakened further. In *N. indicum* there is heterostyly as well as incompatibility and both forms are bisexual. In *N. cristatum* incompatibility system is broken up while heterostyly is advanced to gyno-dioecism. But the process is incomplete. Outbreeding is ensured only in the long-styled flower which has its stamens reduced. Similar reduction also of the gynoeceum in short-styled flower results in dioecism, as in *N. macrospermum* Vasudevan. Thus the three species of *Nymphoides* show evolution of incompatibility system into dioecism for which heterostyly provides the morphological basis.

SUMMARY AND CONCLUSION

Nymphoides cristatum (Roxb.) O. Kuntze. can grow as perennial and flower throughout the year if conditions are favourable. Besides normal vegetative propagation by breaking up of branches, it will produce 'bulbils' from leaves, under dry conditions. It shows gyno-dioecism derived from heterostyly, as a stage in the evolution of dioecism. Heterostyly is not an adaptation to ensure outbreeding but only a morphological modification to bring in dioecism.

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